

CA1
EP540
-1999
C51

Issue

31761 11552843 2

The State of the St. Lawrence River


Saint-Laurent
Vision 2000

Canada

Québec 

The Contribution of Agricultural Activities to the Deterioration of the St. Lawrence River

Since 1950, overall agricultural production in Quebec has risen steadily, despite a decrease in both the area of land cultivated and the number of farm operators. Over the past 30 years, there has been a significant increase in intensive livestock breeding, in particular pork and poultry, as well as continuous corn and potato crops, among others. During this period, the dual phenomenon of specialization and intensification in agriculture has increased pressure on soil and water. Today, there are four main sources of water pollution resulting from farming activities: suspended solids, nutrients, pesticides, and microbial contamination.

Farming causes physical changes to the land that are likely to have an impact on the plant and animal life in and around the St. Lawrence River. These changes may result in, among other things, the drainage and disappearance of marshes and encroachment on riverbanks and the littoral zone. For these reasons, agriculture-related water pollution and physical changes to the environment are a concern.

This fact sheet presents the main conclusions of an analysis of the contribution of farming activities to the deterioration of the St. Lawrence River. It identifies the main agricultural pressures and their impact on the St. Lawrence River, describes measures that have been taken to combat these pressures, and identifies courses of action to mitigate the impact of agriculture on the St. Lawrence River. For further information and a more in-depth analysis of the problem, the reader may refer to the reports listed at the back of the fact sheet.

Sources of Pressure



There are two major categories of agricultural activities which can generate pressure on the St. Lawrence River in Quebec: livestock breeding and crop production. The former is represented by animal production, while fertilization, pesticide use, the area of field crops, and modification and development schemes on farmland and in watercourses characterize the latter.

Over the past four decades, specialization in farming has led to the appearance of disturbances that have affected the environment. The elimination of natural woodlands and windbreaks, the draining and filling of wetlands, the dredging and reshaping of rivers and streams, and modification of the natural characteristics of riverbanks have an impact on the environment, wildlife and recreational activities in various areas.

The improper storage and application of manure is a source of microbial, organic and mineral pollution. In addition, there is a greater risk of soil erosion when land is left without plant cover for a major part of the year (as with

field crops like corn), and runoff carries soil particles into rivers and streams. Nutrients (nitrogen and phosphorus) not absorbed by plants or which exceed the water-retention capacity of soil, along with pesticides, are carried to watercourses in surface runoff or seep through the soil into groundwater.

Figure 1 presents a summary of the main agricultural activities that are sources of pressure and also an assessment of agricultural pressures in the drainage basins of tributaries of the St. Lawrence River. It shows that livestock breeding and corn fields are concentrated on the south shore of the St. Lawrence River between Montreal and Quebec City. The accompanying table provides more detailed information on each of the drainage basins studied with regard to animal production, field crops, and fertilizer and pesticide use.

The Location of Farming Activities Studied

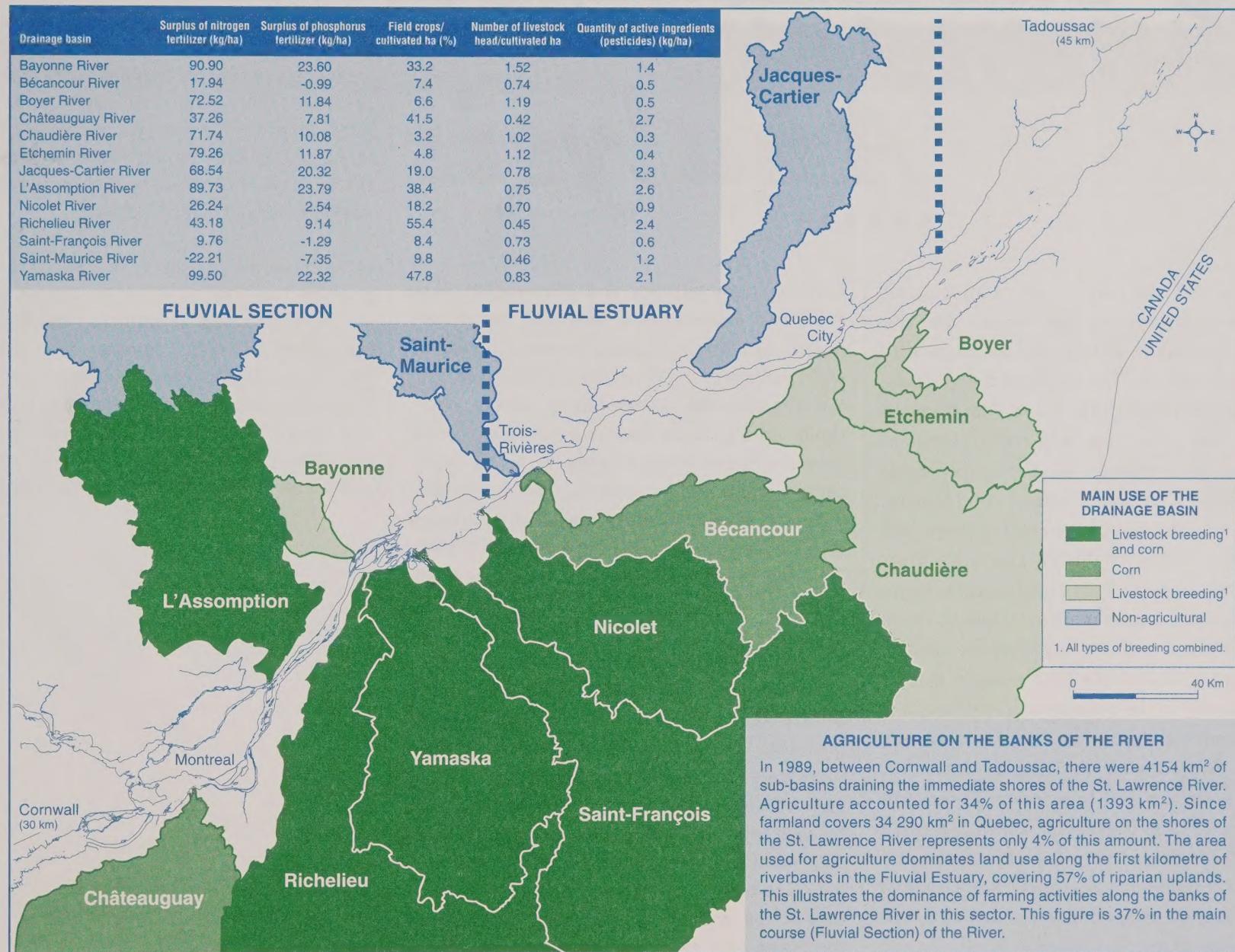
Agricultural pollution differs from other forms of pollution in that it is distributed over a very large area. As a result, most agricultural contaminants that reach the St. Lawrence River arrive via one of its tributaries. In order to understand the impact of farming on the River, we need to consider both farming activities on its banks and those practised in the drainage basins of its tributaries.

Special attention was thus taken to analyse the relationships between farming activities in St. Lawrence drainage basins, the water quality at the mouths of tributaries, and the influence of the tributaries on the state of the St. Lawrence River. We examined eleven drainage basins located in areas where agriculture is a major economic activity, namely the drainage basins of the Chaudière, Yamaska, L'Assomption, Etchemin, Richelieu, Saint-François, Nicolet, Bayonne, Boyer, Bécancour and Châteauguay rivers. These basins are characterized by either a large concentration of animals or a high percentage of land used for corn crops. For comparison purposes, two drainage basins with little farming activity (Jacques-Cartier and Saint-Maurice) were added to the list.

The diffuse nature of agricultural pollution, the hydrodynamics of the St. Lawrence River, and the diversity of control options are a few of the elements that have to be considered in analysing the links between farming and the current state of the River. ■

The Contribution of Agricultural Activities to the Deterioration of the St. Lawrence River

FIGURE 1 Overview of Agricultural Pressures on the St. Lawrence River



Summary Analysis

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In general, the very nature of agricultural pollution makes its impact on the environment extremely variable and difficult to evaluate. The study of the relationships between agriculture and the River is complex due to the diffuse nature of agricultural pollution and the physical modifications brought about by farming activities, the vastness of agricultural areas, and the hydrodynamics of the St. Lawrence River and its tributaries. There are also a large number of local factors at play, including storm events, soil type and use, topography, density, and the proximity of the river system. Due to the complexity of the phenomena involved, it is a considerable challenge to establish accurate, detailed links between agricultural pressures, the state of the St. Lawrence River and responses to these pressures. Tables 1, 2 and 3 present the findings of the *Pressure, State, and Response* components analysed for the issue of the contribution of agricultural activities to the deterioration of the St. Lawrence River.

Certain characteristics and information gaps limit the conclusions that can be drawn regarding the relationships between pressures and the state of the River, on the one hand, and the effectiveness of responses, on the other. While there exists accessible information on the problem, there is uncertainty as to its representativeness and its accuracy. This means that it cannot be used to make precise diagnoses. It is sufficiently reliable, however, to make observations at the regional or drainage basin level.

Based on the information available, it is possible to provide an overview of the status of the St. Lawrence River in terms of agricultural pressure. This data, however, cannot be used to produce a precise assessment of the load of agricultural-source contaminants transported by each tributary, or the possible local effects of each's inflow plume on the St. Lawrence River, owing to hydrological characteristics, the structure of the water-quality sampling network in the River, and sampling frequency, especially

during flood periods. Moreover, with the information available, we can only partially assess the specific contribution of different agricultural activities and the role of inadequate agricultural practices. Of all the unknowns in the issues highlighted in this analysis, we know the least about phosphorus inputs and eutrophication in the St. Lawrence River, and certain aspects of pesticide contamination (Table 2).

In terms of responses, it is important to emphasize that the various initiatives are not specifically aimed at reducing the impact of agriculture on the St. Lawrence River. While it is generally easy to obtain information on the characteristics of these initiatives, most have not been subject to an environmental assessment by which their effects on pressures and on the environment might be determined.

The Contribution of Agricultural Activities to the Deterioration of the St. Lawrence River

Table 1 Findings Regarding Sources of Agriculture-Related Pressures in 1996

Pressure

	Animal Production	Fertilization	Pesticide Use	Field Crops	Modification and Development Schemes
Geographical Distribution	The Chaudière, Yamaska, Etchemin, Bayonne and Boyer drainage basins have the highest number of head per hectare.	Ten of the thirteen drainage basins studied have a surplus of nitrogen and phosphorus (the amount spread is greater than the amount needed by plants).	Pesticide quantities per cultivated hectare are highest in the Yamaska, L'Assomption, Richelieu and Jacques-Cartier river drainage basins.	Field crops take up the largest areas of land in the Yamaska, Richelieu, Nicolet, Saint-François and Châteauguay river drainage basins.	The draining, channelling and digging of rivers and streams is carried out in all of Quebec's agricultural areas; diking mainly takes place along Lake Saint-Pierre and in the Upper Estuary, especially in the area of Kamouraska.
Intensity	Pork production predominates in drainage basins typically dealing with a surplus of manure (Yamaska, Chaudière and L'Assomption).	In a number of drainage basins, phosphorus inputs from farm fertilizer (manure and slurry) exceed plant needs. When mineral fertilizers are considered, application exceeds plant phosphorus and nitrogen requirements by at least an additional 50% and 25%, respectively, in the drainage basins.	Approximately 73% of pesticides sold in Quebec and containing 153 active ingredients are used in agriculture. Half of agricultural pesticides are used on corn crops.	In the Yamaska, L'Assomption, Richelieu, Bayonne and Châteauguay drainage basins, more than 30% of farmland is given over to field crops.	Drained land makes up approximately 20% of farmland in Quebec, or 700 000 ha. In agricultural areas, over 25 000 km of watercourses were developed between 1945 and 1986. Diking affects 388 hectares bordering Lake Saint-Pierre, and approximately 500 ha in the Upper Estuary.
Economic Importance of Agriculture	In 1996, agriculture directly employed 78 300 people in more than 35 000 farm operations. Prior to that, 385 000 people had jobs directly related to the agri-food industry. This figure represented 11.6% of all jobs in Quebec. The Gross Domestic Product (GDP) of the agri-food sector as a whole, estimated at approximately \$12 billion, accounts for almost 10% of Quebec's total GDP. Quebec agri-food exports, worth almost \$2 billion, are expanding significantly.				
Comments	<ul style="list-style-type: none"> Some sources of pressure, such as animals' access to rivers and streams and the physical modification of watercourses, were not described due to a lack of information. The pressures of farming activities on the environment result largely from the lack of complementarity between livestock breeding and crop production. This is a consequence of ever-increasing specialization in agriculture. Despite a few encouraging signs (a reduction in the use of chemical fertilizers between 1986 and 1996 and lower pesticide sales), the pressures exerted by farming activities continue to increase. Sources of agricultural pollution are diffuse and thus difficult to locate and quantify. A significant portion of diffuse agricultural pollution loads to the St. Lawrence River may come from only a small sector of a drainage basin's total area. Pressures resulting from farming activities are not linked solely to the quantities produced but also to production methods. 				

Table 2 Impacts of Agricultural Pressures on the St. Lawrence River

Impact on Water Quality	Animal Production and Fertilization	Pesticide Use	Field Crops	Modification and Development Schemes
<p>Impact on Water Quality</p> <p>Animal Production and Fertilization</p> <p>Agriculture contributes to the phosphorus and nitrogen contamination of the St. Lawrence River. The available information shows that agricultural inputs contribute as much, if not more, to the load of human-source phosphorus in the River as do municipal inputs. Loads of total nitrogen attributed to farming activities have been evaluated, respectively, at 73%, 48%, 34% and 76% of the total flow at the mouths of the Yamaska, L'Assomption, Chaudière and Boyer rivers, with loads of total phosphorus making up 75%, 52%, 56% and 63%.</p> <p>The criteria relative to ammonia nitrogen in the raw water supply were exceeded (2-12% of measurements) on occasion at the mouths of the Etchemin, Chaudière, Bécancour, Nicolet, Yamaska, Richelieu, L'Assomption and Saint-Maurice rivers from 1995 through 1998. No exceedances of nitrite-nitrate or ammonia nitrogen concentrations were observed in the St. Lawrence River.</p> <p>Despite the decreasing trends reported between 1979 and 1994 at the mouths of the Chaudière, Yamaska, L'Assomption, Saint-François, Nicolet, Bécancour, Jacques-Cartier and Saint-Maurice rivers, median concentrations (1989-1994) of total phosphorus exceeded the criteria for the protection of aquatic life. The frequency of criteria exceedances between 1995 and 1998 was greater than 85% in the Yamaska, Chateauguay and L'Assomption rivers, and between 20-50% in most of the other rivers. In the St. Lawrence River, decreasing trends for phosphorus concentrations continued at a majority of sampling stations between 1990 and 1997. This was accompanied by a reduction in the frequency of exceedances of the criteria for the protection of aquatic life between 1990-91 and 1995-96. There was an apparent increase in the frequency of upstream to downstream exceedances in 1995-96, however, but no sign of an increase in concentrations. Agricultural-source phosphorus predominantly takes the form of particles, with inputs occurring primarily during fall and spring flooding, when suspended matter is carried over great distances to the sea. Tributaries draining farmland appear to have a greater influence on water quality in the area of Lake Saint-Pierre.</p> <p>Agriculture appears to contribute little to the poor bacterial quality of the St. Lawrence River, its influence seeming to be local. The bacterial contamination of the water in St. Lawrence tributaries demonstrates the importance of including objectives for the recovery and protection of use of the water at the local and regional level in any agricultural cleanup program. The inadequate storage of manure and slurry, along with improper fertilization and tillage techniques, have a significant impact on the bacterial contamination of surface water by agriculture.</p>	<p>Impact on Water Quality</p> <p>Animal Production and Fertilization</p> <p>Agriculture contributes to the phosphorus and nitrogen contamination of the St. Lawrence River. The available information shows that agricultural inputs contribute as much, if not more, to the load of human-source phosphorus in the River as do municipal inputs. 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Tributaries draining farmland appear to have a greater influence on water quality in the area of Lake Saint-Pierre.</p> <p>Agriculture appears to contribute little to the poor bacterial quality of the St. Lawrence River, its influence seeming to be local. The bacterial contamination of the water in St. Lawrence tributaries demonstrates the importance of including objectives for the recovery and protection of use of the water at the local and regional level in any agricultural cleanup program. The inadequate storage of manure and slurry, along with improper fertilization and tillage techniques, have a significant impact on the bacterial contamination of surface water by agriculture.</p>	<p>Pesticide Use</p> <p>The use of pesticides in agriculture contributes strongly to the contamination of surface water. This problem does not appear to have a significant impact on the St. Lawrence River, however. Only atrazine concentrations occasionally exceed the criteria for the protection of aquatic life, in summer, at the mouths of certain rivers, including the Yamaska.</p> <p>Of all organophosphorus and triazine pesticides analysed, the four herbicides atrazine, cyanazine, simazine and metolachlor were the ones detected in the St. Lawrence River. The Great Lakes constitute their biggest source. The contribution of the tributaries to the load of atrazine in the River is minor (7%), whereas it is more significant for metolachlor (30%). Without taking into consideration organochlorine pesticides, whose use is prohibited, concentrations of these herbicides in the St. Lawrence River are largely below the criteria for the protection of aquatic life and for human consumption. The additive effect of these pesticides is also below the threshold for the expected effect on the aquatic environment. The two organochlorine pesticides used least by Quebec farmers are lindane and endosulfan. Concentrations of these substances do not appear to be increasing between Cornwall and Quebec City, and are below the criteria relative to chronic toxicity.</p>	<p>Field Crops</p> <p>Although farming operations in the drainage basins of St. Lawrence tributaries do contribute to the River's load of suspended solids (SS), it is not possible, based on current information, to determine with any certainty the proportion that can be related to agriculture generally or to different farming activities (including field crops) specifically. Levels of SS in the St. Lawrence River are not a cause for concern.</p>	<p>Modification and Development Schemes</p> <p>Land drainage and excavation work in rivers and streams can aggravate erosion and the transport of SS and contaminants. It is not possible, based on current information, to assess the specific role of such modification to agricultural-source inputs in the St. Lawrence River, however.</p>

Impact on Habitats, Biota and Human Health

Animal Production and Fertilization

The nitrogen situation in the freshwater portion of the St. Lawrence River is not a cause for concern for human health or for the protection of aquatic life. In the case of ammonia nitrogen, occasional exceedances of the criteria relative to raw water supply at the mouths of some tributaries will only have a very localized effect due to the high dilution power of the St. Lawrence River. In the marine environment, the available information indicates no sign of eutrophication in the estuary and gulf from nitrogen inputs in the freshwater inflow of the River, and inputs from the tributaries have not been shown to have any direct influence on coastal areas.

Phosphorus is a nutrient that promotes eutrophication in fresh water. The dynamics of the factors involved and the degree of eutrophication in the St. Lawrence River are poorly understood, both for the River overall and at the local level. Eutrophic indicators in sediment in Saint-François and Saint-Louis lakes have been declining since 1960. Agricultural-source inputs, especially the soluble fraction that is directly assimilated, decrease in summer, a critical growing period for alga and aquatic vegetation, and may even be lower than inputs originating in municipal wastewater. Nonetheless, the gradual saturation of soil with phosphorus following repeated fertilizer applications in excess of plant needs may, in the relatively long term, serve to increase the levels of agriculture-related soluble phosphorus in the St. Lawrence River.

Our existing information does not make it possible to determine the role of agricultural contamination in the St. Lawrence River to the emergence of certain pathogenic agents and sicknesses in Quebec.

Comments

- The size of pollutant loads generated by agricultural sources is extremely variable and depends on a number of factors, such as storm events, soil type and use, topography, density and the proximity of the river system. Fertilization and tillage techniques also play a role, as do adequate manure and slurry storage facilities.
- It is impossible to assess the contribution of each agricultural activity to the contamination of the St. Lawrence River based on the available data, nor can we evaluate the role played by inadequate farming practices.
- The results of water quality analyses (concentration, trend and exceedances of criteria) for conventional descriptors, especially phosphorus and nitrogen, covering the period before 1995, do not necessarily reflect the improvement that may have occurred following the implementation of cleanup measures from 1989 to 1994, primarily in the municipal sector, but also in the agricultural (improved manure and slurry storage facilities) and industrial sectors.
- The method used to filter particulate phosphorus from dissolved phosphorus has the effect of underestimating the former and overestimating the latter with respect to recognized standards. This may have repercussions on the interpretation of water quality data. Owing to this problem, the different forms of phosphorus should be assessed and annual variations determined in

Pesticide Use

Organophosphorus and triazine pesticides are less persistent than are organochlorine pesticides and have a low potential for bioaccumulation. Being within the limits of the protection criteria presupposes an absence of toxic effects on biota and aquatic ecosystems. Without taking into account organochlorine pesticides, whose use is prohibited, the available information shows that the situation of pesticides in the St. Lawrence River does not appear to be harmful for aquatic life or human health. It is possible that locally, in areas influenced by tributary inflow plumes and intensive farming, especially in the Yamaska River, exceedances of the criteria for atrazine and relatively elevated concentrations of triazine herbicides may affect aquatic life in the St. Lawrence River.

Field Crops

SS concentrations in the St. Lawrence River are not attributed to any harmful effect on wildlife. The high solubility of organophosphorus and triazine pesticides significantly reduces the role played by SS in the transport of these contaminants in the aquatic environment.

Modification and Development Schemes

Approximately 34% or 1228 ha of riparian wetland habitat loss along the St. Lawrence River between 1945 and 1988 is thought to be attributable to agricultural development, in particular the draining of riparian areas. Since 1988, an additional 500 to 1000 ha disappeared to agriculture in the Upper Estuary. An estimated 20% (1679 ha) of fish habitat modifications in the riparian environment were caused by agriculture between 1945 and 1988.

There are indirect effects on biota due to habitat loss.

- relation to their source, and to the degree of eutrophication in the St. Lawrence River, in evaluating the contribution of agricultural pressures to phosphorus enrichment in the River.
- Water quality sampling currently being carried out in the St. Lawrence River for conventional descriptors is structured so as to track the River's large water masses. This means that it is impossible to assess the local effects of the tributaries on water quality and aquatic life in areas where their inflow plumes have the most influence.
- Data currently available on pesticides other than organochlorine pesticides in the St. Lawrence River and at the mouths of tributaries flowing through farmland do not cover long enough periods nor do they deal with all sensitive rivers and sections of the River. Furthermore, information on the persistence of these pesticides in water appears to be lacking, in part, while data on the combined effects of pesticides (additive, synergistic, and antagonistic effects) are limited.
- Overall, agriculture has the greatest impact on water quality in the tributaries rather than the St. Lawrence River itself. For the few farms located along its shores, the observed effects are local in nature.

Responses

Table 3 Findings Regarding Responses to Agricultural Pressures

Directed Responses and Effectiveness	Animal Production	Fertilization	Pesticide Use	Field Crops	Modification and Development Schemes
<p>Directed Responses and Effectiveness</p> <p>The industry is increasingly supervised. New regulations on the generation of pollution from agricultural resources (<i>Règlement sur la Réduction de la Pollution d'Origine Agricole, RRPOA</i>) came into force on July 3, 1997. Manure management organizations are operating in three drainage basins. Producers receive subsidies, mostly to upgrade their animal waste storage facilities. In 1997, 45% of major farm operations possessed adequate animal waste storage facilities, for a total volume of 12 million cubic metres of manure stored. This amount represents more than 60% of the problem of point-source pollution by animal waste. The pork industry has adopted its own environmental plan, starting with an examination of production.</p> <p>Some of these measures seem promising. Their effectiveness depends on how conscientious the producers are and on regulatory enforcement. Though proper manure storage improves water quality, we are unable, based on current information, to determine the extent of its influence.</p>	<p>The industry is increasingly supervised. New regulations on the generation of pollution from agricultural resources (<i>Règlement sur la Réduction de la Pollution d'Origine Agricole, RRPOA</i>) came into force on July 3, 1997. Manure management organizations are operating in three drainage basins. Producers receive subsidies, mostly to upgrade their animal waste storage facilities. In 1997, 45% of major farm operations possessed adequate animal waste storage facilities, for a total volume of 12 million cubic metres of manure stored. This amount represents more than 60% of the problem of point-source pollution by animal waste. The pork industry has adopted its own environmental plan, starting with an examination of production.</p> <p>Some of these measures seem promising. Their effectiveness depends on how conscientious the producers are and on regulatory enforcement. Though proper manure storage improves water quality, we are unable, based on current information, to determine the extent of its influence.</p>	<p>Under the RRPOA, agri-environmental fertilization plans will be required to minimize the contamination of water and soil. Manure management organizations are already preparing fertilization plans.</p> <p>Certain farming practices, including fertilization and tillage techniques, have a key role in reducing non-point-source pollution. It is not possible, based on current information, to provide a progress report on these practices in Quebec. Certain indicators suggest, however, that they are not widely employed. Management organizations need time and funding to prove themselves. Their effectiveness will depend on regulatory enforcement.</p>	<p>The phytosanitary strategy adopted by various stakeholders in the field in 1992 and training and awareness programs are helping to change producers' habits.</p> <p>It is too early to tell, but the initial results seem to indicate a certain decrease in pesticide use.</p>	<p>There are no concrete policies aimed at discouraging monoculture. However, parent legislation and a policy are limiting abuses in relation to erosion. Some farm initiatives may also be subsidized.</p> <p>In the absence of more powerful incentives, there is nothing to indicate that these policies encourage producers to change their practices.</p>	<p>The <i>Quebec Environment Quality Act</i> has required a certificate of authorization for any modification scheme on land or in water and its maintenance since 1994. An administrative agreement with a municipality replaces the certificate of authorization for maintenance work by the application of environmental standards aimed at protecting water quality and fish habitat. There are a few very general acts aimed at habitat preservation, and an educational approach is also being promoted. Some local initiatives are aimed at restoring certain habitats.</p> <p>In principle, a certificate of authorization minimizes any adverse effects, if the work is done well. However, in general, the environmental standards for maintaining modified watercourses are not being applied in the majority of municipalities. The effectiveness of other measures is unknown.</p>

Responses

	Animal Production	Fertilization	Pesticide Use	Field Crops	Modification and Development Schemes
Integrated Responses and Effectiveness	Various research, technology transfer, consulting service, training and financial support programs that are aimed at all sources of agricultural pressure rather than just one have been implemented. Some of these programs are new and it is too early to determine their effectiveness. This effectiveness is based in part on producers applying the regulation aimed at reducing agricultural pollution.				
Agricultural Programs with an Environmental Dimension	Until recently, the purpose of most agricultural programs was to increase production; the environment was not a factor. However, MAPAQ has begun to remedy this situation by making government assistance conditional on compliance with certain environmental standards. This is an incentive to get producers to change some of their practices. It is still too early, however, to judge the effectiveness of these initiatives.				
Nonagriculturally-Specific Responses and Effectiveness	Certain cooperative initiatives and approaches have been taken by stakeholders working to improve the condition of the watercourses in some drainage basins. This may include revisiting farming practices with a view to identifying those activities most likely to improve the state of rivers and streams. Such activities are not a structured or formal response aiming at agricultural cleanup.				
Comments	<ul style="list-style-type: none"> Since diffuse agricultural pollutants come from across the province, they cannot (or only with difficulty at a high cost) be concentrated in one location for future treatment. Agricultural initiatives are aimed at mitigating the overall impact of farming on the environment. None target the St. Lawrence River specifically. The fact that most programs are not managed or assessed by drainage basin makes it difficult to verify the relationships between investments made and changes in water quality. The exact proportion of farmers using farming practices which minimize nonpoint-source pollution is unknown. The voluntary approach advocated to change producers' way of doing things is not effective with all farmers and is time consuming. Few resources are allocated for monitoring and following up programs. Most monitoring is of an administrative nature. Since most agricultural pollution is carried to the St. Lawrence River through its tributaries, improving water quality in the River (with regard to agriculture) will necessarily result in action to improve the quality of tributary waters. 				

The Relative Importance of Agricultural Pressures

Given the variety and complexity of the environmental consequences of various farming activities, the relative importance of agricultural pressures requires study. From a decision-making viewpoint, we need to get an idea of the most acute problems in order to respond effectively with the resources available.

However, a discussion of the relative importance of agricultural pressures can be carried out at different levels with different objectives. We can compare various agricultural pressures among themselves, according to their impacts on water quality, riverside communities or biota; we could also try to differentiate direct pressures on the St. Lawrence River from those that are transported through the tributary drainage basins, or we could compare agricultural pressures with municipal pressures.

Water Quality as a Benchmark

Since most agricultural pressures influence the St. Lawrence River through one of its tributaries, responses to a problem observed in or around the River necessarily require action in tributary drainage basins. However, observed and potential problems in the River are not necessarily the same as those in its tributaries, given its powers of dilution and its dynamics. In general, agricultural pollution affects the tributaries more than it does the St. Lawrence River.

Agricultural-source phosphorus, one of the most problematic contaminants in many of the tributaries, does not appear to be as critical in the St. Lawrence River. However, should the saturation of soil with phosphorus continue in these farming basins, inputs could have a much greater impact on eutrophication in the St. Lawrence, especially in the area of Lake Saint-Pierre. The different forms of nitrogen are not a problem in the St. Lawrence River, even in the marine environment, where inputs of sources other than agricultural are high. In the drainage basins of St. Lawrence tributaries, however, agricultural contamination is a problem and a cause for concern. Inputs of SS and pesticide contamination also appear to be greater and more harmful in the St. Lawrence tributaries. Lastly, agriculture-related bacterial contamination affects mainly the tributaries.

Our analysis shows that the effects of agriculture on water quality differ depending on the area being considered within the St. Lawrence drainage basin in Quebec. With the exception, to a certain extent, of phosphorus, the influence of agriculture on the St. Lawrence River does not appear to be a major problem at this time, and the effects are primarily perceptible at the local level.

Riparian Habitats and Biota as a Benchmark

With regard to the impact of agriculture on riparian habitats and biota, it is the location of farming activities that is of most concern.

However, the trend towards agriculture encroaching on the banks of the St. Lawrence River seems to be declining. As for the consequences of deteriorated water quality on biota, and without downplaying the effects of tributary inputs of pesticides and phosphorus locally, our existing information indicates that the overall situation is not worrisome, and that agricultural pollution is not a cause for concern. On the other hand, the poor water quality in the tributaries may affect certain of the River's biological resources (e.g. alter the breeding habits and spawning grounds of Rainbow smelt in the Boyer River).

Farming on the Banks of the St. Lawrence River as a Benchmark

Farming-activities in drainage basins that empty directly into the St. Lawrence River are a small proportion of total agricultural operations in Quebec, and generate only a small portion of the agricultural pressure on the St. Lawrence River. According to some estimates, however, up to 20% of Fluvial Estuary banks and 34% of shores in the Upper Estuary are under cultivation, with discharges being made directly to the River. We cannot presume that the effects of this agriculture are nonexistent. Given its relatively minor scope, however, the observed effects are local.

Agriculture versus Urban Pressures as a Benchmark

Based on our information, we are unable to determine the exact contribution of each

agricultural pressure relative to urban pressure. However, by comparing the stress factors associated with various pressures and taking into account their intensity and scope, it is possible to make some observations regarding the importance of agricultural pressures compared to urban pressures:

- Inputs of phosphorus and nitrogen from agriculture into the St. Lawrence River are considerable. Inputs of suspended solids are considered relatively major, even though assessments for this descriptor are more uncertain and erosion of the riverbanks and bed appears to be vital to the solid load in the River. For other conventional descriptors (BOD_5 and fecal coliforms), contamination of the St. Lawrence River is primarily linked to urban effluent.
- With regard to conventional descriptors, the impact of farming on the St. Lawrence River is felt mostly at the local and regional levels, mainly along the Fluvial Section, and depends largely on the discharge of the tributary in question and the characteristics of the receiving environment (e.g. water flow), as is the case with urban effluent. Agricultural inputs of phosphorus during critical eutrophication periods in summer might be lower than inputs of this nutrient in municipal wastewater.
- Despite the lack of information on the subject, pesticide inputs in Quebec and in various sections of the St. Lawrence River are mainly attributed to the use of these

substances in agriculture rather than to household use.

- Although it is difficult to determine their respective order of importance, riverside areas underwent considerable physical changes due to agriculture up until the 1980s; this was also the case for changes caused by urban activities. By contrast, in the case of agriculture, the situation seems to be stable, and the current potential for physical changes to riparian areas as a result of direct human action, such as encroachment, is mainly associated with urban activities and infrastructure.



Taking Action

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From the perspective of sustainable development, it is perhaps worthwhile to set environmental objectives regarding the issue of the contribution of farming activities to the state of the St. Lawrence River, in order to protect and recover associated uses of the River. At present, there are no recognized environmental objectives¹ aimed specifically at this problem and, given the current state of our knowledge and a few problems particular to the issue, this could prove a difficult task. There is the fact that the contribution of agricultural pressures to the state of the St. Lawrence River has not yet been established with certainty for all the descriptors, especially at the local level; that this contribution varies all along the River and over time; and that we are dealing primarily with diffuse pollution coming from drainage basins of tributaries of the St. Lawrence River, and it is therefore difficult to determine the exact source

on a large scale. Moreover, since agricultural pressures affect St. Lawrence tributaries first and foremost, objectives aimed at reducing or mitigating these pressures in agricultural drainage basins would necessarily have beneficial side-effects for the St. Lawrence River.

Thus, even if no specific environmental objective targeting agriculture and the state of the St. Lawrence exists, there are environmental objectives associated with agricultural activities and pressures for all farmland in Quebec linked to the St. Lawrence River. These objectives are divided into two categories and take different, but often complementary approaches. The first category deals with objectives aimed at reducing or mitigating agricultural pressures by targeting one such pressure or group of activities generating pressure. Included in this category are: the MAPAQ phytosanitary strategy, which is aimed at a 50% reduction in the use of pesticides in farming in Quebec; the regulatory objective that all major producers must have an agri-environmental fertilization plan based on agronomic need; or the objective of agri-environmental and technical advisory clubs to implement concrete measures to

1. An environmental objective is a marker, a threshold or a target relating to a human activity, or to a pressure generated by a human activity, or to an ecosystem component affected by this pressure. The aim of such an objective is to maintain a human activity at a level whereby no serious or irreversible effects are observed on ecosystems; to reduce or limit such pressure to an acceptable level for ecosystems and their associated uses; and to protect, reclaim or restore these ecosystems.

conserve resources, better manage manure, and reduce the use of chemicals. These environmental objectives are directed at the development of more sustainable farming practices, and inspired by a preventative approach to reduce agricultural pressures and conserve resources. They were established without considering the observed effects on the environment, either locally or regionally. The second category of objectives has more of a territorial approach, and is aimed at reducing or mitigating agricultural pressures on a per basin, sub-basin or basin segment basis, taking into account local or regional peculiarities. The objectives are determined as a function of the quality or state of the receiving environment and ecosystems, and also as a function of the recovery or maintenance of uses. This kind of approach to agricultural pressures works best within a context of integrated management that takes into consideration all the pressures affecting the aquatic environment, among other variables.

In addition, some initiatives can be envisioned in light of the main conclusions related to the issue of the contribution of agricultural activities to the state of the St. Lawrence River, and presented in Table 4. This information is separated into various categories that, though not exhaustive, correspond to the main fields of activity that ought to be considered in order to improve the situation.

Table 4 Courses of Action in Response to Agricultural Pressures

Intervention Strategies	Initiatives
<p>• Since agricultural pressures affect first and foremost the tributaries of the St. Lawrence River, objectives aimed at reducing and mitigating these pressures in farming areas will necessarily benefit the River.</p> <p>• Diffuse agricultural pollution originates from all agricultural areas in the province and is difficult to contain in one place for future treatment. Consequently, improved agricultural practices on farms are necessary to reducing or mitigating pressures.</p> <p>• The objectives of reducing agricultural pressures and the measures adopted to meet these objectives are based on two action strategies, the first targeting agricultural pressures and activities regardless of the specific characteristics of the environment, and the second aimed at establishing objectives and measures in accordance with these characteristics. There is cause to evaluate the best combination of action strategies for each problem and for the problem of agricultural pollution as a whole.</p> <p>• Pesticides are by nature toxic compounds and it may prove difficult and expensive to develop a detailed description of contamination and assess all of its effects. What is needed is a preventative approach that includes objectives to reduce pesticide use, regardless of the state of the receiving environment.</p> <p>• Although standard programs and initiatives aimed at reducing agricultural pressures for conventional contaminants can produce results, a territorial approach by drainage basin enables us to better target and adapt action to the state of the receiving environment, taking into account farming characteristics in a given basin. However, few tools and procedures are in place to target such initiatives and determine priorities for action.</p> <p>• A number of subsidy programs for producers fund equipment purchases and the construction of storage facilities for manure and slurry. It is hoped that programs incorporated into other incentives that promote changes to farming practices produce more of the desired results.</p>	<ul style="list-style-type: none">From an environmental viewpoint, farmers are faced with measures and programs that may be contradictory (e.g. crop insurance, which encourages the rigorous use of pesticides according to standards that are not always compatible with the promotion of an integrated pest management approach aimed at minimizing and reducing pesticide use). The harmonization and consistency of measures and programs for producers is conditional on the success of measures to reduce agricultural pressures. <p>Education and Awareness</p> <ul style="list-style-type: none">In order to reduce agricultural pressures, education and training for producers on sustainable, environmentally-friendly farming practices are an important part of the success of any action program.Environmentally-sound approaches and technologies have been developed and more time should be devoted to technology transfer.Training and awareness initiatives do not reach all producers. <p>Regulations and Administrative Measures</p> <ul style="list-style-type: none">Voluntary programs get more members when incentive measures (regulatory, financial or others) aimed at changing practices are introduced at the same time. The implementation of control measures for environmental regulations is important to the effectiveness of all other initiatives.

Table 4 (continued)

Knowledge Acquisition

Pressures

- The accuracy and precision of the description of agricultural pressures vary. There is also little or no documentation on the overall importance of some farming practices and activities that create pressures, particularly animal access to rivers and streams and the physical modification of watercourses. A more accurate overall characterization of agricultural pressures has to take these knowledge gaps into account.
- Since diffuse agricultural pressures are not directly proportional to the quantities produced and it is difficult to accurately locate and quantify them overall, more specific, accurate knowledge of the pressures resulting from farming activities has to take local and regional factors into account (such as soil type, topography and hydrology). A better understanding of cause-and-effect relationships between farming activities and the pressures they create, at the appropriate levels, is necessary to establishing intervention targets. The environmental effectiveness of agricultural practices must also be evaluated so that the best practices available will be recommended.
- It is recognized that the development of sustainable agriculture depends on decreased pesticide use, among other things. A more complete description of pesticide use in agriculture in Quebec would be useful for targeting initiatives aimed at their reduction, and would allow us to monitor use patterns according to these measures.

The Impacts of Pressures

- Pollutant loads and concentrations found in rivers and streams as a result of agricultural pressures are variable and also depend on local and regional factors (such as soil type and use, topography, hydrology and the spatial organization of the agricultural environment and plant cover). Once again, a better understanding of relationships between diffuse agricultural pressures, on the one hand, and pollutant loads and concentrations in receiving rivers and streams, on the other, is required to establish targeted action.
- The sampling of watercourses as now conducted (in terms of station location and frequency of samples) prevents us from adequately assessing the impact of agricultural pressures on water quality in the St.

Lawrence tributaries relative to other sources, or from determining the contribution of each tributary to the contaminant load at its confluence with the St. Lawrence. The knowledge gap is particularly wide in the case of phosphorus. These same factors, combined with a lack of information, including the lack of a model of river hydrology or of the inflow plumes of the tributaries in the River, make it difficult to assess certain potential effects at the local level. The water quality monitoring network for conventional descriptors was not designed with these objectives in mind.

- The knowledge gaps in two areas are substantial. In order to better determine the contribution of agricultural activities to phosphorus enrichment in the St. Lawrence River and its effect on eutrophication, we must first understand the phosphorus situation in the River in terms of the different sources, forms and annual variations, as well as the degree of eutrophication of the River. Second, the information available on pesticides currently in use does not cover long enough periods and does not include all the sectors of the River or the tributary mouths where farming is a major activity. In addition, knowledge of the persistence of pesticides in the aquatic environment is deficient in part, while information on their combined effects is limited.
- The pollution of the St. Lawrence River is a social concern for reasons of preserving and recovering uses of the River. At this time, we do not know enough about the River's flow or the impact of agriculture on uses of the River because there is no complete inventory of these uses and their locations.

The Impacts of Responses

- There is little documentation on the impacts of measures to reduce agricultural pressures and their repercussions on the environment. In light of the limited amount of information available, it appears that the results of these measures are sometimes mixed. Developing and adapting corrective responses requires the ability to assess their effects using appropriate follow-up mechanisms.

The Contribution of Agricultural Activities to the Deterioration of the St. Lawrence River

For more information

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PRODUCTION

Design and Structure

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TECHNICAL PRODUCTION

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ACKNOWLEDGMENTS

We would like to thank all those who contributed to analysing the issue of the contribution of agriculture to the deterioration of the St. Lawrence River, namely:

Ministère de l'Environnement et de la Faune du Québec: Yves Bédard, Richard Desrosiers, Carol Émond, Georges Gangbaz, Stéphane Gariépy, Marcel Gaucher and Serge Hébert

Environment Canada: Jean-François Bibeault, Christiane Hudon, Anne Jourdain and Yves de Lafontaine

Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec: Claude Bernard, Manon Carignan and Richard Laroche

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The State of the St. Lawrence River

St. Lawrence Vision 2000 is an action plan governed by a cooperation agreement between the governments of Canada and Quebec. Its aim is to conserve, protect and enhance the St. Lawrence River, with the ultimate goal of returning use of the river to the population. One of the objectives of the action plan is to improve our knowledge of the St. Lawrence River and to disseminate this information to decision makers, riverside communities and the general public.

This approach is reflected in the fact sheets in the series *The State of the St. Lawrence River*. Its main objective is to collect relevant information about the state of the St. Lawrence in Quebec to provide decision support. The focus is on a series of issues, which are interpreted according to a "pressure-state-response" approach. This approach seeks to identify causal links among the various sources of pressure exerted on the St. Lawrence ecosystem, including natural disasters and human activities, and the state of habitats and resources, and to examine measures taken to counter their effects (existing responses). Each of these environmental issues is the subject of a fact sheet intended for decision makers and those members of the general public for whom the welfare of the St. Lawrence River is a concern. ■



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Published by Authority of the Minister of the Environment

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and Government Services Canada 1999

ISBN: 0-662-26671-4
Cat. No.: En153-97/1999-4-1E

Legal Deposit – Bibliothèque nationale du Québec, 1999
Legal Deposit – National Library of Canada, 1999

Cover page photograph: Michel Boulianne

Aussi disponible en français sous le titre :
*La contribution des activités agricoles à la détérioration
du Saint-Laurent*